

ACTA POLYTECHNICA SCANDINAVICA

ANNOTATED INDEX 1987—1988

HELSINKI 1989

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ABSTRACTS

CHEMICAL TECHNOLOGY AND METALLURGY SERIES

(formerly Chemistry including Metallurgy Series, ISSN 0001-6853)

Ch 178

UDC 541.1:541.13

Lindström, M. and Kontturi, K., *Fifty Years of Physical Chemistry and Electrochemistry at Helsinki University of Technology*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 178, Helsinki 1987, 172 pp. ISBN 951-666-246-3. ISSN 0781-2698.

Keywords: Physical chemistry, electrochemistry, thermodynamics.

The Laboratory of Physical Chemistry and Electrochemistry at Helsinki University of Technology was founded fifty years ago. To notify this occasion the twelve papers of this issue were collected from friends, visitors, and present and former staff of the Laboratory.

Ch 179

UDC 66.013.8:510.22:519.816

Vaija, P. and Dohnal, M., *Fuzzy Methods to Compensate Missing Data and to Evaluate the Relative Importance of Different Contributors in Accident Analysis*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 179, Helsinki 1987, 36 pp. ISBN 951-666-249-8. ISSN 0781-2698.

Keywords: Fuzzy methods, accident analysis.

Three different fuzzy methods to estimate the values of accident consequences corresponding to the values of independent variables describing the accident conditions and to compensate missing data in accident files are presented. Two of the methods are used also to evaluate the relative importance of different accident contributors. The ability of the methods to take into account the vagueness in the data set is discussed. The methods were originally developed for safety studies but are applicable in any field where vague data and the complexity of the process make it difficult to apply conventional models. The methodology is tested with a hypothetical file to guarantee the objectivity of the results. Application to accident analysis is demonstrated with a real accident file.

Ch 180

UDC 66.013.8:510.22:519.816

Vaija, P., *Application of Fuzzy Methods to Process Safety Control and to Accident Analysis*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 180, Helsinki 1987, 26 pp. ISBN 951-666-252-8. ISSN 0781-2698.

Keywords: Fuzzy methods, accident analysis, failure diagnosis.

This thesis is based on six different publications in which the possibility of incorporating vague data and expert knowledge into safety studies is investigated. Here vague data and expert knowledge refer to conditions under which failures and accidents occur, and the consequences of these. Vague data and expert knowledge are often essential in safety studies because of the lack of crisp data and knowledge.

Methods based on fuzzy mathematics are applied, for the reason that fuzzy mathematics allows vague data and expert knowledge be put into a form acceptable to the computer. A simple fuzzy expert system is used to develop failure diagnostic and safety control models for processes with ill-developed mathematical models and poor accuracy of measured data. The diagnostic model of a complex process is decomposed with the aid of a fuzzy switch and several diagnostic algorithms. The diagnostic systems are demonstrated for hypothetical and real polymerization reactors.

The application of three different fuzzy methods i.e. a simple fuzzy expert system, fuzzy linear regression and fuzzified linear programming to the analysis of accidents is discussed. With these methods the experience of past accidents can be exploited for the prediction of consequences of potential accidents. The fuzzy linear regression and fuzzified linear programming can also be used to find the correlations between accident contributors and consequences, and methods based on fuzzy mathematics can be used to estimate missing data in accident reports.

Ch 181

UDC 669.046.545.2:669.046.582.2

Zou, Z., *Thermodynamics of Steel Dephosphorization with Highly Basic CaO-Fe₂O₃ Based Slags*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 181, Helsinki 1988, 86 pp. ISBN 951-666-256-0. ISSN 0781-2698.

Keywords: Steel dephosphorization, CaO slags, ionic theory of slag.

A comprehensive study is made on the earlier thermodynamic models of dephosphorization equilibrium and comments are presented. Laboratory experiments are carried out to investigate the dephosphorization equilibrium of steel with highly basic CaO-Fe₂O₃ based slags. As expected, much greater dephosphorization power is observed for the present slags than for the earlier similar slags since the nonsaturation of the former is obtained by CaF₂ addition while that of the latter is ensured by the presence of acidic oxides. Moreover, the general correlation between the equilibrium quotient of dephosphorization reaction and slag composition observed for slags of low basicity is confirmed and further developed for highly basic slags.

A new ionic composition — the electrostatically equivalent ionic composition — is defined. Temkin's ionic theory of basic molten slag is further developed by the newly defined ionic composition. It is also found that the electrically equivalent ionic fraction in Flood's model merely represents the stoichiometry of the binary reactions and has noway modified Temkin's theory. The newly defined ionic composition is applied to Flood's model and it is found that the model is improved significantly by getting rid of the activity coefficient term in the final relationship. A comprehensive study is made to correlate the theoretical optical basicity with dephosphorization equilibrium. Excellent correlation is obtained between the logarithm of the activity coefficient of P₂O₅ and the optical basicity of the slag. The present experimental results are also examined by this correlation.

Ch 182

UDC 548.5:66.065:532.78

Louhi, M., Silventoinen, I., and Palosaari, S., *Purification of Organic Chemicals by Zone Melting*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 182, Helsinki 1988, 24 pp. ISBN 951-666-258-7. ISSN 0781-2698.

Keywords: Zone melting, fractional crystallization.

Purification of naphthalene and stearic acid by zone melting was studied. The effects of the crystallization velocity and the mixing intensity of the melt on the purity of crystal were investigated by applying the solution of the diffusion equation, where the necessary boundary layer thickness was calculated from correlations in the literature. The calculated values were compared with experimental values. The results of the present work can be used for estimation of the optimum mixing intensity and crystallization velocity.

Nkonde, G. K., *Analysis of Joint Distribution of Number of Cycles and Residence Time in a Selective Recycle System*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 183, Helsinki 1988, 16 pp. ISBN 951-666-263-3. ISSN 0781-2698.

Keywords: Selective recycle, gamma distribution

The first two equations of central moments of the residence time distribution (RTD) derived from the transfer function of a selective recycle system are given. Analysis of the joint distribution of number of cycles distribution (NCD) and RTD and total regional residence time distribution (TRRTD) in a selective recycle comminution system has been analysed using gamma distribution. General mathematical models showing the relationship between the NCD, RTD, and TRRTD have been given in terms of the covariances and correlation coefficients of pairs of those variables.

Laakso, J.O., *Synthesis and Analysis of Some Sulphur and Nitrogen Containing Polymers Including Conducting Polymer Blends of Poly(3-octylthiophene)*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 184, Helsinki 1988, 48 pp. ISBN 951-666-265-X. ISSN 0781-2698.

Keywords: Conducting polymers, processability.

This thesis deals with inherently conducting polymers and has been divided into two parts.

The first part deals with the syntheses, characterization and electrical conductivities of the derivatives of poly(p-phenylene sulphide) and poly(p-azophenylene), poly(2,4-azotoluene), poly(ethylene vinylene sulphide), poly(2,6-pyridine), poly(2,6-pyridine sulphide), poly(3,6-pyridazine) and poly(3,6-pyridazine sulphide). The conductivities were measured using the four probe method. Undoped polymers are insulators (conductivity $< 10^{-8}$ S/cm) but during doping the conductivities rise as high as 10^{-3} S/cm. The doped polymers were studied using IR and ESR spectrometry.

The second part describes the preparation of poly(3-octylthiophene), POT, and the polymer blends of it. POT is solution and melt processable and when doped for instance with iodine the conductivity rises to 20 S/cm. POT has been hotpressed onto a polymer substrate which after doping has a conductivity of 20 S/cm, blended and blow molded with different processable polymers (PE, PP, EVA, EBA). When doped the conductivities of the blends are ~ 1 S/cm. Blends of this type might be useful in applications such as electromagnetic interference (EMI) shielding, electrostatic discharge (ESD) elimination and semiconducting layers in high voltage cables.

Palosaari, S.M., Miyahara, M., Tamon, H., and Okazaki, M., *Adsorption into a Porous Sphere*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 185, Helsinki 1988, 19 pp. ISBN 951-666-271-4. ISSN 0781-2698.

Keywords: Diffusion and adsorption, surface diffusivity and adsorption.

A porous sphere made of adsorptive material is considered. The equation describing simultaneous pore and surface diffusion into a sphere, and with local equilibrium between liquid and solid prevailing, is solved numerically with typical values of pore and surface diffusivities and Freundlich isotherm exponents. Also, surface diffusivity was set to be dependent on solid loading. The results were expressed as concentration in the solid phase as a function of time. It was found that, in most cases, this relationship was with reasonable accuracy the same as the relationship obtained by solution of the equation of simple diffusion in a sphere with a constant diffusivity. However, with very non-linear isotherm the simple diffusion equation predicts a shorter time for attainment of the high solid loading values than what is the case with the more complex model.

Shapovalov, S., Palosaari, S.M., and Lebed, N., *Laminar Vortex Flow in Straight Channel*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 186, Helsinki 1988, 24 pp. ISBN 951-666-274-9. ISSN 0781-2698.

Keywords: Fluid flow rectangular channel, vortex rectangular channel, secondary flow rectangular channel.

Secondary vortex flow was generated in a straight channel of rectangular cross section by a preceding curve. Analysis of the experimental results allowed optimal geometrical dimensions to be calculated for inducing of vortex secondary flow. Secondary flow increases the rate of transfer between liquid and the solid wall with low losses of energy. A theoretical analysis of the vortex intensification of mass transfer in an electrodialysis cell showed this method of enhancing the transfer rate to be effective. Experimental results, using bended plates in the flow channel for vortex formation, confirmed the finding.

Nordén, H.V., Sirén, M. and Westerlund, L.M., *A Short-Cut Method to Calculate Multicomponent Distillation*. Acta Polytechnica Scandinavica, Chemical Technology and Metallurgy Series No. 187, Helsinki 1988, 29 pp. ISBN 951-666-276-5. ISSN 0781-2698.

Keywords: Distillation, short-cut methods.

A method is presented for calculating multicomponent distillation in staged columns. Equations, somewhat similar to those of Underwood, are derived, and then simplified by applying the properties of modified concentrations. Calculation procedures making use of the simplified equations are summarized for seven different case problems.

CIVIL ENGINEERING AND BUILDING CONSTRUCTION SERIES

Ci 86

UDC 624.15:519.6

Puttonen, J., *Boundary Element Analysis for Dynamic Loading of a Circular Plate on an Elastic Medium*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 86, Helsinki 1987, 87 pp. ISBN 951-666-241-2. ISSN 0355-2705. Keywords: Boundary element method, plate on an elastic medium.

This study examines the behavior of a circular plate on an elastic medium and the applicability of the boundary element method to solving the problem. The loading can be dynamic or static. The dynamic problem was solved in the frequency domain by the Fourier transform technique. The stiffness values of the medium were defined by impedance functions determined for a rigid and massless plate. Equations based on the direct and indirect boundary element methods were derived for a plate on a one- or two-parameter elastic medium. Computer programs based on the direct and indirect boundary element methods were developed on the basis of the theory presented. Several examples were calculated to test the computer programs and to demonstrate the behavior of a plate on an elastic medium. Comparisons were also made of the applicability of the boundary element method, on the one hand, and the finite element method, on the other, to solving the problem. The practical examples presented relate to the behavior of the foundation plate of a nuclear power plant. The study shows that the boundary element method is applicable to the static and dynamic analysis of a plate on an elastic medium.

Ci 87

UDC 625.712:756.13

Saarnivaara, V-P., *Cross Section Design of Residential Streets Based on Meetings Between Motor Vehicles*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 87, Helsinki 1988, 53 pp. ISBN 951-666-247-1. ISSN 0355-2705. Keywords: Residential street, vehicle type, meeting, traffic, volume, variation, turning, cross section, design.

The traffic volume and the number of trips, the factors that affect them, the daily and hourly variations, the percentages of vehicle types, the turning behavior and the number of meetings between motor vehicles of different type driving in opposite directions were examined during 208 count days on 113 residential streets in selected areas of low-rise housing in 33 Finnish municipalities. A method is created for cross section design of residential streets based on time intervals between meetings of motor vehicles of different type. Models to estimate the number of trips and the daily traffic are also presented in this report.

Ci 88

UDC 528.73:681.3.02:519.23

Sarjakoski, T., *Automation in Photogrammetric Block Adjustment Systems — On the Role of Heuristic Information and Methods*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 88, Helsinki 1988, 125 pp. ISBN 951-666-260-9. ISSN 0355-2705.

Keywords: Photogrammetric block adjustment, aerial triangulation, automation, artificial intelligence, knowledge-engineering, heuristics.

Automation in photogrammetric block adjustment systems is studied, especially the role of heuristic information and methods in automatic systems. The purpose of a block adjustment is considered in the context of the whole mapping process and of the other systems involved in that process. It is shown that heuristic information related to a block adjustment appears in connection with incomplete integration of

system components. Heuristic methods are related to the models and strategies used in the block adjustment. The block adjustment is understood to comprise two major subtasks: an optimal adjustment and a subsequent quality evaluation. It is discovered that increased sophistication in adjustment models leads to increase in the need for heuristic information. An outline is given of the items to be checked in the quality evaluation. The problematics of detecting and correcting gross errors is studied in depth. State-space representation is used in the detection of gross errors to emphasize the distinction between goal definition (problem formulation) and the solution techniques. Heuristic techniques are necessary to overcome the computational complexity of the problem. The close relation between heuristic search techniques and weight reduction methods is clarified: weight reduction methods can be interpreted as heuristic search techniques. The studies on the distribution of test values used in the detection of gross errors reveal that in practice heuristic approximations must be used. A technique based on Bayesian classification is introduced as a means of utilizing a priori information of the quality of each individual observation in the detection of gross errors.

Ci 89

UDC 622.271.333:622.281.74:622.831.3:624.127

Feng, D., *Slope Stability Analysis Under Three-Dimensional Stress Condition and Stabilization Design of Cable Bolting*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 89, Helsinki 1988, 101 pp. ISBN 951-666-261-7. ISSN 0355-2705.

Keywords: Slope stability, stress, cable bolting.

In this thesis, slope stability analysis under three-dimensional stress condition and stabilization design of cable bolting in slope engineering are described. The new analysis model connects elastic theory with block theory to develop a slope stability analysis program. This model can take into account stress condition and different geological discontinuities at the same time. Cumulative failure percentage of slope angles and the relation between the safety of slope angles and the quantity of cable bolting are given as analysis results.

The design of stereo photogrammetry of geological surveying and geological data presentation are introduced. Three-dimensional stress calculation mesh and stress estimation method are also presented. Slope stability analysis and slope stabilization of cable bolting are described in detail. A set of calculation methods with graphical presentation of the results which concern above topics are given and applied in practice. Finally, this model has been used in Kemi mine. All results of analyses have been approved by the mine.

Ci 90

UDC 624.2/.8:624.041:657.47

Rautakorpi, H., *Material Quantity and Cost Estimation Models for the Design of Highway Bridges*. Acta Polytechnica Scandinavica, Civil Engineering and Building Construction Series No. 90, Helsinki 1988, 176 pp. ISBN 951-666-266-8. ISSN 0355-2705.

Keywords: Bridge, model, material, quantity, cost estimation.

Mathematical quantity and cost estimation models for highway bridges are constructed. Unknown coefficients are determined through regression analysis based on statistical samples of real bridges. The following types of bridges are treated: reinforced concrete slab bridges, prestressed concrete girder bridges and composite steel bridges with two main girders. Abutments and intermediate supports are treated separately. Models are used for cost estimation, structural optimization and design supervision.

Ci 91

UDC 556.124.2:528.88

Kuittinen, R., *Determination of Areal Snow Water Equivalent Using Satellite Images and Gamma Ray Spectrometry*. Acta Polytechnica Scandinavica, Civil Engineering

and Building Construction Series No. 91, Helsinki 1988, 139 pp. ISBN 951-666-275-7. ISSN 0355-2705.

Keywords: Snow water equivalent, satellite imagery, gamma ray spectrometry.

A method is studied for near real time estimation of the areal snow water equivalent in the snow melt period. The method involves direct estimation of the areal snow water equivalent and the use of satellite images, gamma ray spectrometry and field measurements in estimating snow water equivalent. The method also involves estimation of snow melt by satellite images and field measurements. First, the areal distribution of the snow and the factors affecting it during the snow melt period are studied. A method is introduced for estimating the snow water equivalent on the basis of the area of bare spots on the ground interpreted from satellite images. The errors in estimating the snow water equivalent are between 20 and 45 mm for point estimates. The accuracy of gamma ray spectrometry and the factors affecting it in snow water equivalent measurements are studied. On the basis of these measurements, the representativeness of point snow water equivalent estimates is evaluated. A snow melt equation based on the degree-days and global radiation is also studied. Finally, daily areal snow water equivalents are estimated for 1986 in the Kemijoki river basin and the results are compared with measured stream flows. The errors in daily areal snow water equivalents were between 15 and 35 mm.

ELECTRICAL ENGINEERING SERIES

El 57

UDC 537.8:530.19

Alanen, E., *Exact Image Principle in Electromagnetic Field Computation*. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 57, Helsinki 1987, 32 pp. ISBN 951-666-242-0. ISSN 0001-6845.

Keywords: Electromagnetic analysis, antenna theory.

The paper summarizes ten publications constituting the thesis for the degree of Doctor of Technology. The publications present the basic idea and mathematical formulation of the exact image principle for electromagnetic field calculation and several applications of the principle. The principle can be applied in problems with planar interfaces, such as antennas near the ground surface, microstrip structures, field radiation through the interface, or radiation in biological media. It is assumed that all the media are isotropic and the fields are time-harmonic. The exact field solutions are presented using continuous image current distributions which are situated partly in complex space. Three of the papers present the basic principle with a comparison to Sommerfeld integration. The remaining seven papers present applications of the method: the effect of the ground on the input impedance of short vertical dipoles, power line field calculation, radiation of a horn antenna in contact with the human skin, and microstrip field calculation.

Advanced Summer School on Microelectronics: Physics and Technology for VLSI. Proceedings of Advanced Summer School on Microelectronics: Physics and Technology for VLSI, Kivenlahti, Espoo, Finland, June 8—12, 1987. Edited by Tor Stubb and Riitta Paananen. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 58, Helsinki 1987, VI + 221 pp. ISBN 951-666-248-X. ISSN 0001-6845.
Keywords: Microelectronics, VLSI.

The purpose of this year's Summer School was to give a review of novel topics in physics and technology for VLSI. The School was intended for post graduate students and research people in this field. These proceedings contain the invited foreign papers presented at the School.

Arkko, A., Analysis of Induction Motors Based on the Numerical Solution of the Magnetic Field and Circuit Equations. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 59, Helsinki 1987, 97 pp. ISBN 951-666-250-1. ISSN 0001-6845.
Keywords: Induction motors, finite element analysis.

A method for the analysis of induction motors is presented. The analysis is based on the combined solution of the magnetic field equations and the circuit equations of the windings. The equations are discretized by the finite element method. The magnetic field is assumed to be two-dimensional. The three-dimensional features i.e. the skew of the rotor slots and the end-region fields are taken into account within the two-dimensional formulation. The general time-dependence of the field and the motion of the rotor are modelled correctly in a step-by-step solution. The amount of computation is reduced significantly if the time-dependence is assumed to be sinusoidal and phasor quantities are used in the solution.

The method is applied to the calculation of a cage rotor motor and of a solid rotor motor. The sinusoidal approximation gives good results in the computation of steady-state locked-rotor quantities, but it does not model the motion of the rotor properly. The step-by-step method is used for computing machine quantities in steady and transient states. For instance the operation of the solid rotor motor supplied by a static frequency converter is simulated. The results obtained by the method agree well with the measured ones.

Kerttula, E., Error Characteristics and Simulation of Error Control with Quality Criterion in 9600 bit/s Public Switched Telephone Channels for Digital Group 3 Facsimile. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 60, Helsinki 1987, 230 pp. ISBN 951-666-245-0. ISSN 0001-6845.
Keywords: Digital facsimile, facsimile quality, error control, channel measurements, channel modelling.

An experimental instrument for measuring detailed error sequences on real communication channels, for analyzing the results and for simulating several error control schemes for digital facsimile is developed and its operation described. Several national and international 9600 bit/s channels using CCITT V.29 transmission technique on public switched telephone network (PSTN) and 9600 bit/s channels on Nordic circuit-switched data network were measured and new results of their error characteristics are given. The recorded channels were also compared with several models. The 4-state Markov model according to R.H. McCullough provides a very good numerical fit to the pooled PSTN channels. The Bose-Chaudhuri-Hocquenghem and Reed-Solomon codes for reliable Group 3 facsimile are presented and were simulated. Error correction inside the scrambler/descrambler pair and error correction with interleaving are also discussed and were simulated. A new transmission-time local distortion measure is defined and a new family of distortion controlled Automatic Repeat Request (d*ARQ, Hybrid-d*ARQ) schemes for reliable Group 3 facsimile are introduced and were simulated.

Li, L., *Boundary Element Method for Three-Dimensional Magnetostatic Fields in Terms of Vector Variables*. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 61, Helsinki 1988, 58 pp. ISBN 951-666-253-6. ISSN 0001-6845.

Keywords: Magnetic field, boundary value problems — numerical solutions.

This thesis deals with a boundary element method for three-dimensional magnetostatic problems. The analysis is performed in terms of the magnetic flux density or the magnetic vector potential, and the developed method offers wide range of application. Uniqueness conditions are presented for some boundary value problems in magnetostatics. A set of vector boundary integral equations is derived. The integral equations are approximated by applying the point matching or Galerkin method, and the formulations of isoparametric boundary element solution are developed for linear homogeneous problems. A novel interpolation method is introduced to take the special features arisen in magnetostatics into consideration, and a numerical scheme catering for the singularity in integral equations is described. The technique for homogeneous problems is extended for interface problems with modification. Numerical examples are given for both homogeneous and interface problems.

Takala, J., *A Study of EMI-Endurance of Two Polling-Type Local Area Networks Used in Real-Time Automation Applications in a Simulated Electrical Environment*. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 62, Helsinki 1988, 109 pp. ISBN 951-666-254-4. ISSN 0001-6845.

Keywords: Performance, reliability, risk, availability, automation system, local area network (LAN), real-time application, electrical disturbance.

The study presents and verifies three modelling ideas — disturbance generator, applying risk and availability area — to be used in the planning, testing and using of real-time automation applications installed in EMI-environments (electromagnetic interference), for the evaluation of EMI-endurance of a local area network (LAN) used on the process data bus level. The effect of the electrical disturbances is taken into consideration by the disturbance generator. It takes into consideration some parameters affecting the EMI-endurance of a LAN — the physical installation, some parameters of the data communications, and of the electrical transient disturbances. In the experimental and simulatory research this problem is apportioned into three parts: the generation of messages, and disturbances and the network. By this research the time stationary probability distributions of the performance and unreliability are evaluated as a function of the disturbance voltage. By using the time stationary probability distributions of EMI-levels measured from field conditions, and the above mentioned probability distributions, the applying risks and availability areas of a LAN-based system can be evaluated in different EMI-conditions.

Advanced Summer School on Microelectronics: Progress in Sensor Technology. Proceedings of Advanced Summer School on Microelectronics: Progress in Sensor Technology, Kivenlahti, Espoo, Finland, June 14—17, 1988. Edited by Riitta Paananen and Markku Ylilampi. Acta Polytechnica Scandinavica, Electrical Engineering Series No. 63, Helsinki 1988, VI + 181 p. ISBN 951-666-273-0. ISSN 0001-6845.

Keywords: Microelectronics, sensor technology.

The subjects of this year's Summer School covered novel topics in sensor technology. The school was intended for post graduate students and research people in this field. These proceedings contain the invited papers presented at the School.

MATHEMATICS AND COMPUTER SCIENCE SERIES

Ma 47

UDC 681.3

Bergqvist, J.T., *A Type-Oriented Approach to Knowledge-Based Systems*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 47, Helsinki 1987, 232 pp. ISBN 951-666-243-9. ISSN 0355-2713.

Keywords: Knowledge-based systems, knowledge representation, artificial intelligence, modelling.

A type-oriented programming (TOP) approach to building knowledge-based problem solving systems is developed. A problem solving system is considered as a system of knowledge elements. Each knowledge element class consists of a set of knowledge items, possibly inherited along class structures. Both elements and their items are given knowledge types. A knowledge type defines a knowledge representation and consists of a set of type aspects, possibly inherited along type structures. A knowledge type can be instantiated to give values to the aspects and, thus, to create a realisation of a more general representation. Knowledge types are made use of when typed signals are sent to knowledge items or elements. In TOP, signals are processed by interpretations which are signal and receiver type-specific functions. Types can be active (operator), passive (value) or context creating (knowledge organising) in nature. Using the TOP approach, a multilevel context architecture for modelling and solving problems of high knowledge intensity is proposed. TOP is compared with a number of well-known knowledge-based programming paradigms and tools. For instance, the if-then rules are considered as a special case of representing active knowledge.

Ma 48

UDC 681.3

Takala, T., *Methodological and Structural Principles for Flexible Geometric Modelling in Computer Aided Design*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 48, Helsinki 1987, 30 pp. ISBN 951-666-244-7. ISSN 0355-2713.

Keywords: Geometric modelling, computer-aided design.

This thesis gives an interdisciplinary view of computer aided designing. Based on the foundations of design theory, a transaction model of the design process is presented, which corresponds to the composition of an object model from the basic interactive operations. Geometric modelling aspects are discussed mathematically, and the solid boundary representation (BR) scheme is generalised to all dimensions, including computer graphics. This unified methodology makes it possible to construct geometric object models from basic graphical actions. Finally, the architectural aspects of CAD systems to support the flexible methodology are discussed, and an object-oriented approach is suggested as the most natural paradigm. The author's experimental AGX system, based on these flexible modelling principles, is presented with concrete design examples.

Ma 49

UDC 658.1

Koski, T.H.A., *Ownership Strategy and Competitive Advantage*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 49, Helsinki 1988, 203 pp. ISBN 951-666-257-9. ISSN 0355-2713.

Keywords: Strategic management, stock ownership, financial planning, internationalization.

In terms of theories and concepts, competitive advantage has so far been studied from the point of view of both business strategy and organizational strategy. In this study, the scope of competitive advantage

is enlarged to a third dimension created by ownership strategy, analyzed at both corporate and strategic business unit levels. A framework is provided to help clarify this. The focal point of the model is the way corporate assets are valued and utilized by corporate management and existing or potential shareholders. The role of corporate management is to create an equilibrium between the aspirations and expectations of the shareholders and the business strategies of the corporation. The matching process is carried out in terms of the corporation's ownership strategy.

The ownership strategy is based on a proper understanding of the behavior of different owner/investor groups. Traditional classification is founded on their institutional origin. The thesis defines a new classification based on owners'/investors' differing preferences for investment criteria. Based on this, an analysis can be made of the impact of ownership strategies at corporate and strategic-business-unit levels on competitive advantage.

The dynamics of the model are based both on changes in business life cycles and the globalization process. These changes strain a firm's ability to transfer the competitive advantage found in one part of the company to other parts of the firm. This ability is defined as linkage of competitive advantage. The concept of linkage of competitive advantage also reflects the matching of corporate governance structure and operational organization structure. Thus, it also measures the matching process between the competitive advantage created by the organizational strategy and ownership strategy. It is inevitable that in complex governance structures the structure starts to define strategies; corporate management no longer conducts strategies but rather the context in which strategies are conducted.

Ma 50

UDC 519.85:519.688

Aittoniemi, L., *Basis Representations in Large-Scale Linear Programming Software*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 50, Helsinki 1988, 60 pp. ISBN 951-666-268-4. ISSN 0355-2713.

Keywords: Linear programming, LU-decomposition, LU-update, product form inverse, sparse matrices, direct methods.

This thesis discusses the most sophisticated kernels of simplex-based linear programming software: computation of an LU-factorization for a given basis matrix and its update in subsequent LP-iterations. Besides mathematical aspects, emphasis has been placed to find the proper implementation of the algorithms.

On each simplex iteration the basis representation is updated either in product form or as an LU-factorization. Two sets of linear equations are solved on each iteration; these operations are called forward and backward transformations. In this thesis the total computing time spent in the update and forward and backward transformations is compared in different approaches. The author's contribution to a new, sparse LU-factorization is discussed, and a new implementation of an efficient LU-update is presented. New data structures are developed which reduce the time complexity of the factorization and updates as well as forward and backward transformations. Numerical experiments with large real-life test problems demonstrate the superiority of the new techniques.

Ma 51

UDC 007.52:681.3:681.5.015

Vähä, P., *Application of Parameter Adaptive Approach to Servo Control of a Hydraulic Manipulator*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 51, Helsinki 1988, 86 pp. ISBN 951-666-269-2. ISSN 0355-2713. Keywords: Adaptive control, manipulators, microprocessor control, hydraulic systems, filtering.

A method for compensating changes in manipulator dynamics to cope with the increased requirements for better servoing performance of manipulator motion is introduced. The dynamic model of the manipulator arm is linearized and presented in a state space form. The parameters of the linearized model are estimated on line and used for tuning of the servo controller. The control of the manipulator is experimentally examined in computed path control, both for a regular and irregular path. The test runs are carried out with a loaded and unloaded manipulator.

A simulation study with simple process models is utilized to further examine the adaptive properties of the method. The ability of the estimator to track changing parameters during path servoing are examined and the significance of the velocity in adaptive servo control applications outlined. Further, the derived

control law is verified and the effects of feedforward and feedback parts both together and separately are examined with constant multivariable processes in servo applications. The results indicate the applicability of the method for servo control of manipulators.

Ma 52

UDC 658.512.6:65.014.13:681.3.019

Hynynen, J., *A Framework for Coordination in Distributed Production Management*. Acta Polytechnica Scandinavica, Mathematics and Computer Science Series No. 52, Helsinki 1988, 94 pp. ISBN 951-666-270-6. ISSN 0355-2713.

Keywords: Distributed production planning and control, hierarchical organizational coordination, distributed artificial intelligence.

Coordination of information processing in a distributed production management environment is studied. For this purpose, a framework coined as DREAM (Distributed Reactive Management) is specified. DREAM is based on a hierarchically decentralized set of opportunistically behaving decision-making subsystems, communicating with each other via message passing. The subsystems themselves are threefold entities, each comprising a Problem-Solving Subsystem, a Domain-Modeling Subsystem, and a Message Management Subsystem. An individual decision-making subsystem in DREAM is relatively self-contained, communicating with its environment on a reactive basis. The actual internode coordination in DREAM is collectively in the hands of the individual Message Management Subsystems. They apply a set of temporal, topological, and application dependent rule-based heuristics to regulate the internode message traffic. The regulation takes place both in contents and in magnitude. The messages passed contain various constraint information to guide and constrain the local decision making. Application of the message-processing heuristics allows both vertical and lateral communication amongst the system components. The framework thus enforces opportunistic network behavior, and facilitates the resolution of possible conflicts and opportunities both in predictive and reactive contexts. The methodological commitments made are justified with a sample implementation for factory scheduling. The implementation is coined as BOSS (Bunch of OPIS-like Scheduling Systems), as it based on the existing OPIS (Opportunistic Intelligent Scheduler) scheduling system. A pilot manufacturing system has been a medium-sized production line for multilayer printed boards for professional electronics. Experiments with the implemented system show that the DREAM framework clearly enforces the principle of the desired balance of being predictive, and yet reactive in real world activity planning and control.

MECHANICAL ENGINEERING SERIES

Me 88

UDC 66.01:621.181:62.002.2 007.52:159.95

Riitahuhta, A., *Enhancement of the Boiler Design Process by the Use of Expert System Technology*. Acta Polytechnica Scandinavica, Mechanical Engineering Series No. 92, Helsinki 1988, 122 pp. ISBN 951-666-272-2. ISSN 0001-687X.

Keywords: Boiler plant, design process, expert system, teamwork, design rules, product development, computer-integrated manufacturing (CIM).

An analysis of boiler plant design skills was carried out among plant design companies to establish a basis for enhancing the boiler plant design process. The system developed as a result of this uses an artificial intelligence computer and expert system technology. The goals set for the system have been attained, and plant design will change into product development.

APPLIED PHYSICS SERIES

Ph 156

UDC 533.9:621.039.61

Heikkinen, J., *Studies on Parametric Instabilities in High-Frequency Wave Heating of Fusion Plasmas*. Acta Polytechnica Scandinavica, Applied Physics Series No. 156, Helsinki 1987, 27 pp. ISBN 951-666-240-4. ISSN 0355-2721.

Keywords: Plasma, heating, parametric instabilities.

The effect of secondary wave coupling mechanism on various parametric instabilities in plasmas aimed to fusion applications is investigated theoretically in this thesis. Harmonic generation of the low-frequency wave is found to reduce well the reflectivity of Brillouin scattering and to suppress the convective growth of the lower hybrid decay instability. Saturation of Raman scattering by ion wave coupling of the low-frequency mode is also obtained.

Interestingly, a very complicated (apparently chaotic) time behaviour for weakly damped waves is observed illustrating the strong nonlinearity inherent in the wave equation systems describing the previous processes. In addition to these nonlinear studies, an evaluation of the linear threshold for the parametric scattering of the heating wave in electron-cyclotron resonance heating of tokamak plasmas is presented.

Ph 157

UDC 550.837.61

Aittoniemi, K., Rajala, J. and Sarvas, J., *Interactive Inversion Algorithm and Apparent Resistivity Versus Depth (ARD) Plot in Multifrequency Depth Soundings*. Acta Polytechnica Scandinavica, Applied Physics Series No. 157, Helsinki 1987, 34 pp. ISBN 951-666-251-X. ISSN 0355-2721.

Keywords: EM measurements, frequency sounding.

Theoretical and experimental aspects of multifrequency electromagnetic depth soundings were studied using a fixed harmonic multifrequency source. Measurement data were collected using frequency sweep and ratios of magnetic field components. For preliminary and fast interpretation, illustrative apparent resistivity versus depth (ARD) plots were used. For a more detailed investigation, an interactive inverse algorithm based on the layered earth model was developed.

The interpretation methods were applied to depth sounding measurements from two areas in Finland. Frequencies from 2 Hz to 10 kHz and coil separations from 300 m to 880 m were utilized in recording the two independent ratios B_z/B_r and B_z/B_t between the orthogonal horizontal components B_r and B_t and the vertical component B_z of the magnetic field. The sounding results are presented in the form of ARD plots, and a more detailed interpretation is performed by the interactive algorithm. The results show that the ARD plot gives a useful preliminary estimate of the resistivity structure; this estimate can be used as a starting point for the interpretation with the interactive algorithm, which, in a favorable case, yields satisfactorily accurate results.

Ph 158

UDC 621.3.045:537.635:61

Savelainen, M.K., *Magnetic Resonance Imaging at 0.02 T: Design and Evaluation of Radio Frequency Coils with Wave Winding*. Acta Polytechnica Scandinavica, Applied Physics Series No. 158, Helsinki 1988, 67 pp. ISBN 951-666-255-2. ISSN 0355-2721.

Keywords: Nuclear magnetic resonance, magnetic resonance imaging, radio frequency coils, instrumentation.

The thesis deals with the theoretical principles, design and construction of wave-wound radio frequency coils for low field magnetic resonance imaging. The coils can be tuned to emit and detect circularly polarized radio frequency field. The principles and design of the tuning circuit are described. The performance of the wave-wound coils and tuning circuits is analyzed on the basis of numerical simulations and experimental studies. Guidelines for the design of high performance coils are given. Four wave-wound coils have been designed and constructed for clinical magnetic resonance imaging. Properties and examples of the imaging results of these coils are presented.

Ph 159

UDC 539.1.074:539.12

Ellilä, M., *On the Performance of the DELPHI Hadron Calorimeter*. Acta Polytechnica Scandinavica, Applied Physics Series No. 159, Helsinki 1988, 49 pp. ISBN 951-666-259-5. ISSN 0355-2721.

Keywords: Calorimetry, wire chambers, plastic streamer tubes, LEP, DELPHI, electron-positron collisions.

A short review is given of the high-energy physics studied at electron-positron colliders. The principles of hadronic energy measurement in experimental high-energy physics are introduced. The Electron-Positron storage ring (LEP), now under construction at CERN, is presented together with its experimental program, of which the DELPHI experiment is introduced in detail. The design and operation of the DELPHI Hadron Calorimeter are given an introductory treatment.

Ph 160

UDC 550.837.81:519.64

Soininen, H., *A Study of the Relationship Between Apparent and Petrophysical Spectral IP Response by Numerical Modeling*. Acta Polytechnica Scandinavica, Applied Physics Series No. 160, Helsinki 1988, 20 pp. ISBN 951-666-262-5. ISSN 0355-2721.

Keywords: Spectral induced polarization method, electrical methods, numerical modeling, galvanic anomalies.

This paper summarizes five papers that deal with the numerical modeling of galvanic anomalies and the behavior of the apparent phase spectra in the spectral induced polarization method. In the case of one body with Cole-Cole polarization embedded in an unpolarizable half-space, the apparent phase spectrum closely resembles the petrophysical Cole-Cole spectrum in functional form. Of the Cole-Cole parameters inverted from the anomaly spectra, the chargeability is noticeably smaller than the chargeability of the petrophysical spectrum. The apparent frequency dependence is very close to its true value. The shift of the apparent phase spectrum toward lower frequencies partly compensates for the decrease in the apparent time constant caused by attenuation of the spectrum. The apparent time constant is thus close to the true time constant. The effect of a polarizable half-space may be handled by simply adding the phase spectrum of the half-space to the apparent phase spectrum due to the body. The apparent spectrum of several bodies builds up in a complex fashion. Nevertheless, measuring the spectra at a number of points along a profile crossing over formations differing in time constants permits the various components to be discriminated from the apparent spectra, even if the difference in time constants is small.

Ph 161

UDC 538.911:538.958

Oikkonen, M., *X-Ray Diffraction and Ellipsometric Studies of Zinc Sulfide Thin Films Grown by Atomic Layer Epitaxy*. Acta Polytechnica Scandinavica, Applied Physics Series No. 161, Helsinki 1988, 46 pp. ISBN 951-666-264-1. ISSN 0355-2721.

Keywords: X-ray diffraction, ellipsometry, ZnS, thin film, crystallite size, microstrain, refractive index, density.

The microstructure of ZnS thin films grown by atomic layer epitaxy (ALE) is investigated using x-ray diffraction and a single-line technique. Crystal structure, preferred orientation, crystallinity, crystallite size, crystallite size distribution and microstrain are determined. Complex refractive indexes of the films are determined in the wavelength range 400—600 nm using spectroscopic ellipsometry. A two-layer model is employed, where the uppermost layer takes into account the surface roughness. Density of ZnS thin films is determined using ellipsometry and He⁺-ion backscattering spectrometry.

In the first tens of nanometers of an ALE ZnS thin film the crystallinity and void content strongly depend on the substrate properties. Most of the films have been grown on soda glass. It is found that after the bottom layer, at the distances from 50—100 nm to 300—400 nm from the substrate the crystallinity is good, crystallites are large, the specific orientation is strong, the void content is low and the optical properties resemble those of bulk ZnS. At distances larger than 300—400 nm the surface roughness and the void content in the upper parts of the film are increasing because of the more and more randomly packed large crystallites. Substrate temperature and source materials affect the growth of all parts of the film.

Ph 162

UDC 620.179.1

Jaarinen, J., *Nondestructive Evaluation of Coatings by Low-Frequency Thermal Waves*. Acta Polytechnica Scandinavica, Applied Physics Series No. 162, Helsinki 1988, 58 pp. ISBN 951-666-267-6. ISSN 0355-2721.

Keywords: Nondestructive testing, thermal wave imaging, characterization of coatings.

The use of low-frequency thermal waves for nondestructive testing and characterization of coatings has been studied. Three different experimental techniques have been presented for the characterization of three different types of coatings. Firstly, the detectability of coating adhesion defects by means of scanning thermal wave microscopy has been analyzed. It has been shown that thermal waves can be used for the quantitative determination of the thermal contact resistance at a defective coating/substrate interface and that an optimum frequency exists for the detection of defects. The technique has been applied to the characterization of adhesion defects between a plasma sprayed Cr₂O₃ coating and a steel substrate. Secondly, a method has been developed for the determination of the thickness of thermally thin metallic films on nonmetallic substrates. The method is based on the detection of the lateral thermal wave propagation by the transverse OBD technique. Experiments were carried out on measuring the thickness of submicron copper films deposited on a glass substrate. The third kind of coating studied here is surface hardened steel. It is shown by presenting an inverse solution of the heat diffusion equation that the thermal wave surface data is in principle sufficient for the reconstruction of the thermal conductivity and thermal diffusivity profile associated with surface hardening. For the practical characterization of these coatings a heuristic method has been developed. The accuracy obtained in the determination of the nominal hardening depth is of the same order as can be obtained by the commonly used destructive Vickers measurement.

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